NEW SERIES No. 30.

SELECTIONS FROM THE RECORDS

OF THE OFFICE OF THE

FINANCIAL COMMISSIONERS, PUNJAB.

Published by Authority.

No. 55.

CONTENTS.

No. LXXXIV.—Land Surveys as executed by the Survey of India Department; and the resultant maps.

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Lahore:
PRINTED BY THE SUPERINTENDENT, GOVERNMENT PRINTING, PUNJAB,
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N.B.—Please see also Selection No. 26 (old series), No. LIV, page 607.

Note by the Superintendent, Northern Circle, Survey of India, on Land Surveys, as executed by the Survey of India Department; and the resultant maps.

SECTION I.—Surveys.

Points of general application.

Definition of Land Surveying.

Land Surveying is the operation of accurately determining, and representing on paper, the relative position of the features, both natural and artificial, of a portion of the earth's surface.

Purposes and classification.

The purposes for which Land Surveys in India have been carried out may roughly be divided into 3 classes, *viz.*:—

(*i*) for the preparation of topographical and geographical maps of the country.
(*ii*) for revenue purposes.
(*iii*) for miscellaneous purposes, *e.g.*, archæological, and geological maps, Town plans, etc., etc.

To a great extent the different classes are interdependent.

Basis of Land Surveys.

Land Surveys for all these classes of purpose are, or should be, based ultimately on the same basis, *viz.*, the net work of triangulation extended over the whole country by the Great Trigonometrical Survey of India.

Connecting Link.

The connecting link between the figures of this principal net-work of triangulation and the detail survey is either:—

(A) Minor triangulation.
(B) Traversing.
(C) A combination of (A) and (B).
(D) In the case of surveys for revenue or settlement purposes, rectangulation.

Fundamental principle.

The principle governing, or which should govern, the execution of all survey operations is that of working from the whole to the part, thereby restricting and practically eliminating accumulative error. The practice, which has sometimes obtained in the execution of surveys for revenue purposes, of working from the part to the whole has been conducive of an accumulation of error which has vitiated the whole operation.

Thus, in the case of land survey for revenue purposes, certain points, at comparatively wide intervals, are fixed by one or other of the methods above referred to as connecting links, and the detail survey, in this case field measurement, is carried out and adjusted between these fixed points.

The accuracy of the resultant map will thus ultimately depend on that of the frame work on which it is based, which, in its turn rests on the data of the Great Trigonometrical Survey the accuracy of which is, for all practical purposes, absolute.

Explanation of terms descriptive of the basis of Land Surveys.

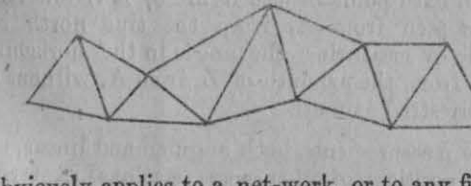
Triangulation.

To deal now with the linking operations in the order in which they have already been enumerated.

Triangulation is the practical application of the elementary proposition of trigonometry that, given the angles of a triangle and the length of one side, the lengths of the other sides can be ascertained by calculation.

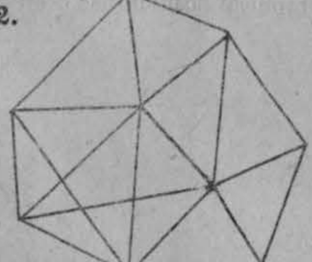
If, then, we have a chain of triangles, as below, and know all the angles and the length of one side, we can compute the length of all the other sides.

Fig. 1.



The same obviously applies to a net-work, or to any figure built up of triangles.

Fig. 2.



Now imagine that these points are objects on the earth's surface and that at each object horizontal angles have been observed to those surrounding it, and suppose that the horizontal distance between any two of these points has been measured, it is clear that the distance between any two connected points is easily computed and plotted on paper.

The measured side is called the *base*.

Triangulation is divided into 3 classes, *viz.*, Principal, Secondary and Minor, all depending on the same trigonometrical principle but each successive class employing smaller figures whose angles are measured with smaller instruments and less degree of refinement than the preceding one.

Instruments used.

The instrument used for the measurement of these angles is the theodolite whose size is designated by the diameter of the horizontal plate on which are engraved the degrees, minutes and seconds of the horizontal arc.

In ordinary settlement survey 5 and 6 inch vernier theodolites are used while the frame work is generally done with a 7 inch theodolite.

A transit theodolite is one in which the telescope can be rotated vertically end for end, and in which the vertical circle is graduated throughout its circumference.

Triangulation of the Punjab.

The whole of the Punjab is beautifully covered with points triangulated by the Survey of India, and their Geographical values as well as the distances between them and their bearings with the true North line are accurately known.

Application of triangulation to Settlement Survey.

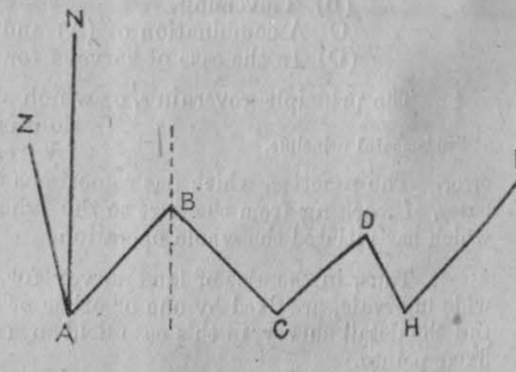
As triangulation is more expensive than traversing for the purposes of Settlement Survey, it is resorted to only with a view to fix important points, generally 5 to 10 miles apart, in flat country, or in a hilly tract where traversing is impracticable.

Traversing.

A traverse consists of a connected series of straight lines (on the earth's surface) of which the lengths and bearings have been determined.

For instance if in figure 3 below the angles at B. C. D. and H. have been observed with a theodolite, and distances A.B., B.C., C.D., D.H., and H.F., have been measured either with a steel tape, or a chain, the points A. B. C. D. H. F. can be plotted on paper in their correct relative positions.

Fig. 3.



Azimuth Observations.

If now the position of A on earth's surface is known, *i.e.*, if A is a point previously accurately fixed, and the direction of A. B. in relation to the true north, *i.e.*, the angle N. A. B. (where N. is true north) is known, the correct positions on the earth's surface of all the remaining points B.C.D.H. and F. are known, and can be correctly placed on paper by plotting.

The direction of A.B. in relation to the true north, or, as it is called, the azimuth of A.B., is obtained by measuring, with the theodolite the angle at A. or B. between B. or A. and, in the day time, the centre of the sun or, at night, a star, at a time when it can be ascertained from the Nautical almanac and a knowledge of the observer's position on the earth's surface, that the centre of the sun or star subtends, at the point of observation, a certain angle in the horizontal plane with the true north. An azimuth, so obtained is known as a sun or astronomical azimuth, and is as a rule, taken once a day when running a line of traversing. In cases when a second fixed point Z. (see figure 3) is visible from A, its azimuth, or the deflection of its direction, as seen from A, from the true north being known, the azimuth of B. from A. is obtainable by measuring the angle in the horizontal plane Z. A. B. and adding it to, or substracting it from, the azimuth of Z. from A, without observation to the sun or star. This is known as a terrestrial azimuth.

Traverse—Computations and plotting.

The computation of traverse measurements, both angular and linear, aims at giving the positions of all traverse stations in terms of chains and links, measured due north or south and due east or west, of a point, which is known as the origin, whose geographical position has been trigonometrically ascertained.

For purposes of plotting these traverse points 2 straight lines are drawn on the paper intersecting each other at right angles at the point selected to represent the position of the origin on the paper, and the co-ordinates (northings and southings, westings and eastings) of the traverse stations are measured at right angles to these rectangular co-ordinates of origin, and the position of the point on the paper determined by the intersection of such measurements.

Proving a traverse and adjustment of error.

If in the diagram (Fig. 3) the position of F. as well as that of A. be previously known, the position of F. as obtained by the method of traverse just described, can be compared with its known geographical position. This is called "proving a traverse." Any discrepancy of the position of F. as so disclosed would then be eliminated by the application of a proportionally decreasing adjustment in the co-ordinate values of each successive traverse station H. D. C. B. back to A., no alteration of course being made in the co-ordinate values of A. This is known as adjusting for traverse error. If the traverse be run in a circle A. & F. become identical.

Use of fixed points.

Traverses for fixing points for cada stral surveys are generally run between two known points, or in a polygonal figure starting from, and closing on, the same point. The angles are observed with a theodolite, and in a flat country, the distances are measured either with a steel tape, or a chain. Where the ground is hilly and rugged the distances are often measured with a subtense bar.

Subtense bar.

The principle of the subtense bar method is the measuring by a system of repetition on the horizontal circle of a theodolite, the angle subtended by a bar of known length placed horizontally and at right angles to the ray of which the length is required.

Distance between traverse stations.

Traverse stations should be as far apart as possible consistent with the ultimate object of the traverse; that is to say, in the case of traverses along boundaries, the positions of the stations are governed to a great extent by the fact that off-sets from the traverse line to the turnings of the boundary should not exceed 100 feet or so in length.

Marking of traverse stations.

All stations are marked as required by the settlement authorities according to the nature of the ground.

Ordinarily pegs 2½ feet long, and 4 inches in diameter are used.

Description of Traverse circuits.

The theodolite traversing is divided into two classes :—

(*a*) Main circuits.

(*b*) Sub-circuits.

(*a*) Main circuits are carried with the object of preparing very accurately the preliminary frame work in a country unsuited for triangulation. A six or seven inch theodolite, generally reading to ten seconds, is used for observing angles and the distances are measured with a crinoline steel tape 330 feet, or so long. The lines are taken in favourable ground about 40 or 50 chains long and as far as possible, at angles nearing 90° or 180°. The errors allowed in this work are—In angles one minute per 20 stations; in distance one in 3,000 to 5,000.

(*b*) Sub-circuits are run to supply points for the detail and boundary survey. Generally 20 to 30 stations are fixed per square mile. The angles are observed with a 5 inch theodolite and the distances are measured with a 100 feet steel, or iron chain. Two chains of different lengths are used to avoid gross errors, generally a 100 foot and a 66 foot chain. The angular error allowed is generally one minute per five stations and the linear error one in five hundred.

Rectangulation.

Rectangulation is an operation of land surveying which is practically confined to surveys for revenue and settlement purposes. It consists in dividing a tract into a series of rectangles generally, 990 feet by 1,100 feet equal to 25 acres in area. The object of rectangulation is that it facilitates partition, the calculation of revenues for the purposes of irrigation and settlement, and the distribution of waste land for colonization.

Rectangulation done by the Survey of India is based on a scientific traverse. The corners of certain selected rectangles forming blocks of 100 rectangles, or so, are first laid out on the ground, with the help of traversed points, and the blocks are then broken into individual rectangles. The 25 acre rectangles are again sub-divided by patwaris into 25 smaller rectangles each equal to one acre, and are called *killas*. Thus the unit of calculating area becomes exactly an acre for all purposes.

Description of different classes of detail surveys.

Turning now to the detail survey of the different classes of Land Survey in the order in which they have already been named at the commencement of this section.

Topographical Surveys. Recent history of—

The first systematic topographical survey of the entire Indian Empire was commenced in 1906, and it was then estimated that about 25 years would be occupied in the completion of the work. This estimate is likely to be exceeded. Thereafter topographical surveys will probably be revised periodically at intervals of about 25 years.

Scales of Modern Topographical Surveys.

The topographical surveys of the greater part of India are on the scale of 1 inch = 1 mile, but there are large areas of the less densely inhabited regions which will be surveyed on the ½ inch scale and others, mostly in the mountainous regions, which are being or will be surveyed on the scale of 4 miles = 1 inch.

On the other hand Forest Surveys are being done on the scale of 2 inches and 4 inches = 1 mile and cantonments are suveyed on that of 16 inches = 1 mile.

The system employed in all topographical surveys of representing the configuration of the ground is contouring or the running of lines each representing constant altitudes above mean sea level at certain fixed vertical intervals. These vertical intervals are, in the case of surveys on the 1 inch scale, 50 feet, in that of those on the ½ inch scale, 100 feet and in that of those on the scale of 4 miles = 1 inch, 250 feet.

Surveys for Revenue and Settlement purposes—

Methods.

Inaccuracy in the past.

The method usually employed in adapting scientific surveys to revenue and settlement purposes is broadly speaking, a more or less rectangular chain measurement and off-setting from lines of theodolite and chain traverse. It has in the past at times been extended to very undue distances from these traverse lines, and great inaccuracy, due to an unchecked accumulation of error, has been attained.

Rectification of error in the Punjab.

This inaccuracy in the Punjab is now being systematically determined and eliminated as new settlements are undertaken, and this is especially the case in the riverain areas, in which errors due to lack of scientific method in the first place have been complicated by the destruction of marks by river action.

Riverain Surveys.

These riverain areas are those covered by village lands which are wholly or partly situated within the radius of action of a river, and all classes of surveys carried out in such villages are called Riverain Surveys.

Genesis of.

Some years ago it was decided by the Punjab Government that on all the rivers the boundaries between various villages falling in the riverain area, should be permanently fixed. With this object in view local surveys were carried out by various officers on practically all the rivers, and maps were prepared fixing the boundaries permanently, but, as these surveys had not been based on any scientific skeleton, the result was that when the settlement maps were reduced to the scale 4″ = one mile, and a congregated map was prepared with the help of certain pakka trijunctions and settlement base line pillars which had been picked up with a theodolite traverse, the various boundaries did not lock up, and serious discrepancies were discovered. It was, therefore, decided in the year 1904 that, while compiling the 4 inches riverain sheets, all discrepancies under two chains should be ignored; and others shown, and that these latter should be settled at the time of district settlement. As the procedure decided on during the year 1904 regarding the use of the 4″ riverain sheets did not prove entirely satisfactory at the time of the Gurdaspur Settlement, it was considerably modified in the years 1907 and 1908.

Present procedure.

The present procedure is as follows :—

First the congregated sheets of the riverain area are compiled on the scale 4 inches to a mile, showing all the village boundaries and discrepancies of over two chains in amount, including a good portion of the pakka on both sides. This is a preliminary work which has been done for the greater part of the Punjab.

When a district comes up for settlement, the Settlement Officer decides as to which of the riverain villages should be completely surveyed, and which should be partly measured In the first case, the pakka as well as the kacha areas are traversed, while, in the second, the kacha, and only the village boundary on the pakka, are traversed. In both cases sufficient points are fixed by a theodolite traverse on the ground to enable all boundaries, patches of cultivation, etc., to be surveyed. The whole area is then ruled into one single system of squares, or rectangles suited to the local unit of measurement.

" Masavis " (settlement mapping sheets) pertaining to this system are then taken up, their indexes and headings are written, and the best evidence that can be obtained from old data regarding the position of the village boundaries is marked upon them ; while plots are prepared on the local scale for each village or sub-village separately on the duplicate copies of the masavis, showing points relating to the particular village or sub-village. The masavis are then handed over to the Settlement Officer who surveys all the detail, and also the boundaries existent on the ground, by off-setting from traverse lines ; and where boundaries cannot be found, enters his decision with the help of the evidence already marked on the masavis. The preliminary work is finished as early as possible in the season so as to enable the Settlement Officer to complete his measurements in the same season in which the traverse is done. After this, on both sides of the river, base lines, consisting of three corners of a square, generally facing one another, and appertaining exactly to the same system of squares or rectangles on which the plots are supplied, are fixed on the ground with the help of traverse points ; so that the maps can always be used for " girdawari," or other purposes, in the usual way, by reconstructing the intermediate squares or rectangles from the pakka base lines.

In hilly tracts points are laid out partly by traverse, and partly by triangulation, and the plotted masavis, showing the points for each village, are supplied to the settlement authorities in the same way as is done in the riverain area.

Field surveying.

When plotted masavis have been supplied, the patwaris should not content themselves with the points which have been plotted on them, but they should fix more points within the plotted points, by means of the plaintable where the ground is hilly and broken, or by breaking lines joining any two plotted points, and distributing the small error proportionately. The number of such points should vary with the nature of the ground and the size of fields to be mapped.

Generally the lengths of offsets taken to corners of fields should not exceed 100 feet. Measurements to detail should be made by simple offsetting only, *i.e.*, measurements should never be made along lines which are offsets to lines which themselves are offsets from the traverse line, as this tends to multiply error.

SECTION 2—MAPS.

For revenue and settlement purposes.

How supplied.

The maps of those land surveys which are carried out by the Survey of India Department for revenue or settlement purposes are now usually supplied by the Department in original form, reproductions, if required, being arranged for by the Civil authorities to whom the originals are delivered.

Method of preparation.

These maps are in the nature of compilations, at least as far as concerns the district and tahsil skeleton maps, which are prepared by reducing the musavis of the area by pentagraph to the scale of the traverse or rectangular plot, and fitting them in on the latter between points of the traverse or rectangulation which are common to both the skeleton bases and the musavi.

Here again the fundamental principle of working from the whole to a part is followed.

Reduction of error.

The common points are generally village trijunctions which have been picked up on the traverse, and whose position is therefore in terms of the traverse. The fitting in process tends to correct the musavis, since the disclosed error is absorbed by proportional distribution throughout its area.

Scale.

The traverse or rectangular plots, as being prepared from computed data, can be plotted to any scale on which it may be considered desirable to have the resulting map. The scale on which maps for revenue and settlement purposes have usually been plotted and drawn has been 16 inches = 1 mile, though this scale has been by no means universal in the past.

Topographical and other maps.

Topographical maps. Publication of—

Topographical and other maps prepared by the Survey of India however are required in comparatively large numbers, and therefore are made available in the form of publications, the originals being retained and carefully stored in the Department.

Scales.

The ordinary scales of publication of these maps are 1 inch, ½ inch and ¼ inch = 1 mile, but with the exception of maps on the last named scale, they will not be universal for the whole of India. The ¼ inch scale will be that of the maps of all but the higher portions of the mountaneous frontiers and desert or undeveloped tracts, while only the more developed portions of the country, including most of the provincial areas, will be mapped on the 1 inch scale.

Included areas.

Each sheet published on this last-named scale includes an area of 15 minutes of latitude × 15 minutes of longitude, and contains the survey of some 250 square miles (more or less) of country. The mileage area contained within any specified geographical limits depends on the latitude of the area as a whole, since the further north it be the smaller is it in terms of square miles.

In the case of surveys published on the $\frac{1}{2}$ inch scale the map measures 30 minutes of latitude by 30 minutes of longitude and in that of the degree sheets ($\frac{1}{4}$ inch = 1 mile) their geographical content, as their descriptive name implies, is a square degree.

Special maps.

In addition to these there are the publications of the maps of the special topographical surveys to which reference has already been made under section I—Surveys, *e.g.*, forest surveys, cantonment surveys, &c., which are generally on the same scale as that of the surveys.

Geographical maps. Preparation of—

From the 3 ordinary scales of publication just described what are classed as geographical maps are prepared by reduction, without further survey, and are published on the following scales :—

Scales and titles.

(*i*) 1 inch = 15·783 miles, called the $\frac{1}{\text{Million}}$, or India and Adjacent Countries Series, each sheet covering 4 degrees of latitude by 4 degrees of longitude.

(*ii*) A special or international edition of this series each sheet of which covers 4 degrees of latitude by 6 degrees of longitude.

(*iii*) 1 inch = 31·566 miles called the $\frac{1}{\text{2 Million}}$, or Southern Asian Series each sheet embracing 4 sheets of the $\frac{1}{\text{Million}}$ series.

(*iv*) 1 inch = 63·132 miles, called the $\frac{1}{\text{4 Million}}$ General Map of India and embracing the whole area comprised in these $\frac{1}{\text{Million}}$ sheets which deal with the Indian Empire.

(*v*) General map of India on the scales of 32, 64, 80, 96, 192, 256 miles = 1 inch.

Features of geographical maps.

The $\frac{1}{\text{Million}}$, $\frac{1}{\text{2 Million}}$ and the Special or International edition of the former are layered maps, *i.e.*, the general shape of the ground is shown by the application of a flat tint of a particular colour to all areas whose altitudes above mean sea level fall within certain limits, other tints or colours being applied to each other area lying within pairs of successive selected altitudes above mean sea level. The hill features on most of these maps are further brought out by shading.

Numbering of Maps.

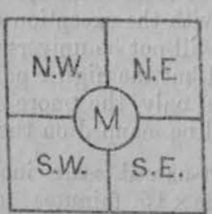
$\frac{1}{\text{M.}}$ series and larger scales.

The $\frac{1}{\text{Million}}$ and larger scale ordinary Topographical maps are now numbered on a system which makes reference simple and is as follows :—

(*a*) The sheets of the $\frac{1}{\text{Million}}$ series are numbered from 1 to 136 in accordance with the Index to that series a portion of which (sheets 32 to 73) appear in the Index opposite.

(*b*) For the sheets of the degree sheet series each $\frac{1}{\text{Million}}$ sheet is sub-divided into 16 degree sheets, each of which is distinguished by a capital letter of the alphabet; see Index opposite and key to Degree sheets in the inset.

(*c*) For the $\frac{1}{2}$ inch series each degree sheet area is divided into quarters which are described as N.-W., S.-W. N.-E., and S. E., thus :—



This has not been shown on the Index opposite.

(*d*) While for the 1 inch series each degree sheet is divided into sixteen 1 inch sheet areas, numbered 1 to 16 according to the arrangement shown in the key to standard sheets on the index opposite.

Thus a sheet of the $\frac{1}{\text{Million}}$ series is described by its number only, *e.g.*, sheet No. 45; a degree sheet by the number of the $\frac{1}{\text{Million}}$ map in which it falls with the addition of the Capital letter indicating its position in that map, *e.g.*, No. 45 A.; a half inch sheet in the same way with the addition, in the form of a denominator to the Degree sheet capital letter as a numerator, of the letters of the quarter of the latter with which it deals, *e.g.*, No. 45; $\frac{\text{M.}}{\text{N. W.}}$, and a 1 inch sheet by the degree sheet number and letter with its own appropriate number in the form of the denominator of a fraction of which the degree sheet letter forms the numerator, *e.g.*, No. 45 $\frac{\text{M}}{12}$.

Other maps. All other maps not belonging to one or other of the 4 series whose system of numbering has just been explained are given special titles and are numbered on a system of their own somewhat different in each case.

Sources of supply of Published Maps.

On payment. All maps published by the Survey of India can be obtained on application with payment from the Officer in charge, Map Record and Issue Office, Survey of India, 13, Wood Street, Calcutta, or from Agents who, in the Punjab, are :—

Messrs. Rai Sahib Munshi Gulab Singh & Sons, Government Publishers & Booksellers, Lahore,

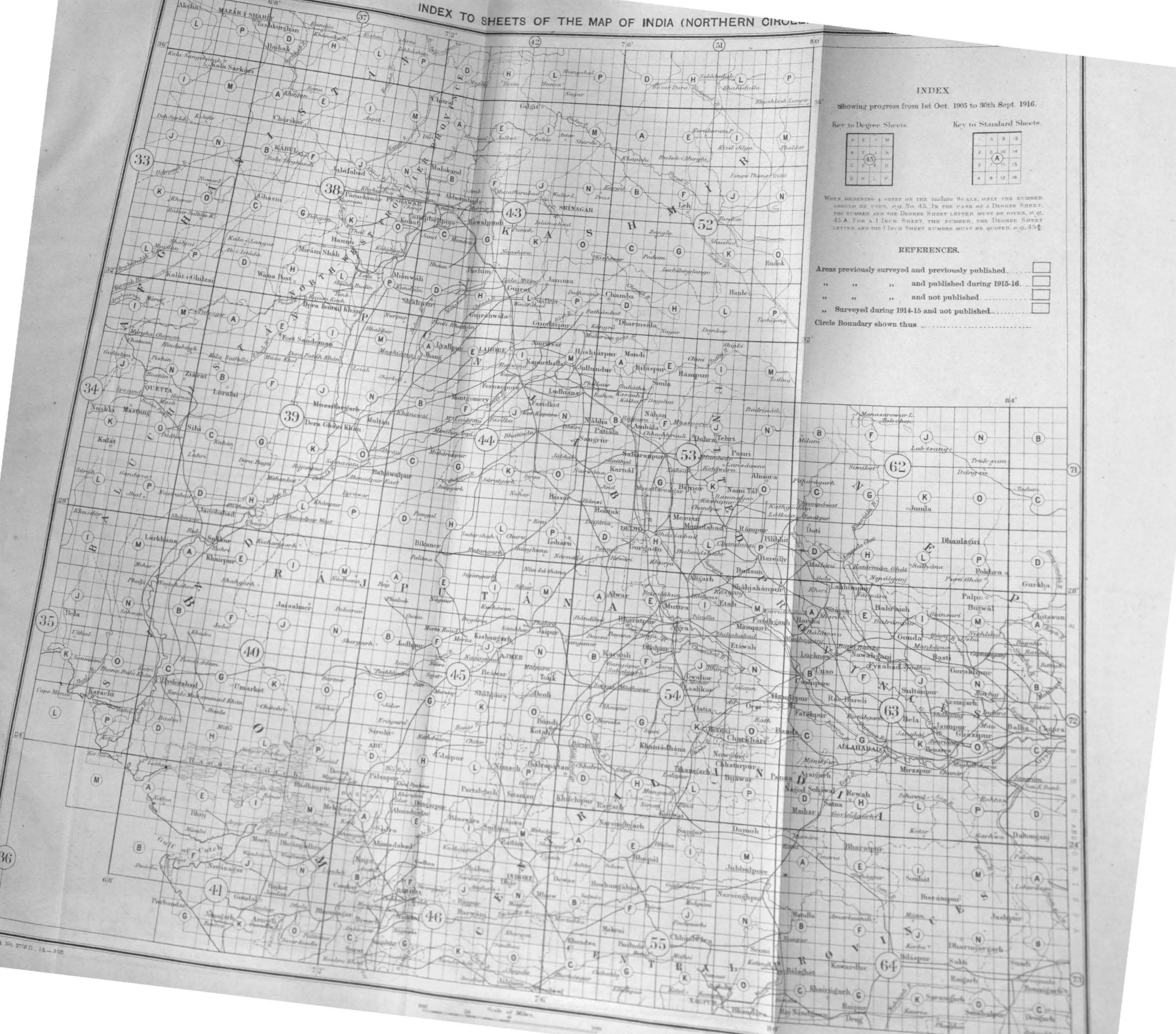
and

Messrs. Thacker Spink & Co., Simla.

The Officer in Charge, Map Record and Issue Office, will despatch maps issued on payment V. P. P. if asked so to do.

On Government Service. Maps required on Government service are issued by him free of charge, but maps obtained through the Agents must be paid for.

266 FC—102—29-11-16—SGPP Lahore.


INDEX TO SHEETS OF THE MAP OF INDIA (NORTHERN CIRCLE
INDEX
Showing progress from 1st Oct. 1905 to 30th Sept. 1916.
Key to Degree Sheets.
Key to Standard Sheets.
When ordering a sheet on the Scale, only the number should be used, e.g. No. 45. In the case of a Degree Sheet, the number and the Degree Sheet letter must be given, e.g. 45 A. For a 1 Inch Sheet, the number, the Degree Sheet letter and the 1 Inch Sheet number must be quoted, e.g. 45 A/8.
REFERENCES.
Areas previously surveyed and previously published
" " " and published during 1915-16.
" " " and not published
" Surveyed during 1914-15 and not published
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